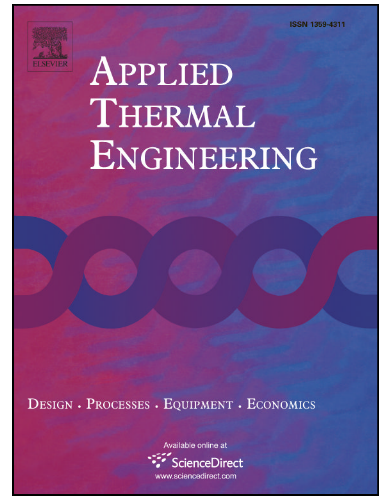

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Experimental and numerical study of coal dust ignition by a hot particle

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Abstract
This work studies the ignition of a layer of brown coal dust by hot metal particles experimentally and numerically. The experiments establish the limits of the flaming ignition of gas and ignition delay times when the parameters of solid fuel and metal particles varied in a wide range. The particle size of coal ranged from 0.1 to 1 mm; the shapes of the metal particles were sphere, disk, and cube; their initial temperature varied between 1000 and 1400 K. A mathematical model was developed for describing the processes involved in heat and mass transfer as well as chemical reactions around the local heat source. The results of the numerical simulation are in good agreement with the experimental data: boundaries of the flaming ignition of coal; coal ignition delay times; three modes of flaming ignition of coal with the ignition zone of volatiles located in the vicinity of the hot particle. The mathematical model is good at predicting the ignition conditions during interaction between a hot metal particle and a layer of coal dust. The model can also be used for developing the promising technology of steam boiler start-up by highly reactive coal instead of flammable liquid combustion. Another application is the development of fire prevention guidelines for tightening fire safety management at productions deal with coal mining, transportation, storage, processing, and combustion. Finally, the paper includes the analysis of limitations for the practical use of the predictive mathematical model in thermal power engineering and fire safety management.
Keywords: ignition, layer of coal dust, hot particle, mathematical model.

Nomenclature and units

C	specific heat ($J \times kg^{-1} \times K^{-1}$)
D	diffusion coefficient (m^2/s)
E	activation energy (J/mol)
k	pre-exponential factor (s^{-1})
Q_1	heat of volatiles oxidation in air (J/kg)
Q_3	heat of coal thermal decomposition (J/kg)
q_p	density of radiation heat flux from a hot particle ($W \times m^{-2}$)
r, z	coordinates (m)
r_p, z_p	sizes of a hot particle (m)
r_l, z_h	solution domain sizes (m)
R_t	perfect gas constant ($J \times mole^{-1} \times K^{-1}$)
T	temperature (K)
T_0	initial temperature of air and coal (K)
T_d	temperature of thermal decomposition of coal (K)
T_p	initial temperature of hot particle (K)